CLAIMS

We claim:

1. A Q-switched microlaser comprising:

a) a resonant cavity formed between a first mirror and a second mirror;

b) a Yb^{3+}:YAG medium disposed within said resonant cavity for producing laser gain;

c) a pump source for energizing said gain medium; and

d) a saturable absorber disposed within said resonant cavity; said saturable absorber, said second mirror, and said laser gain being selected so that output pulses having a duration of less than about 1 nanosecond are generated.

e) two undoped pieces diffusion bonded to outer surfaces of saturable absorber and gain medium

2. The laser of claim 1 wherein said second mirror is an output coupler having reflectivity R, R≤ $T_{sa,closed}$, where $T_{sa,closed}$ is the initial , unbleached transmission of said saturable absorber to the microlaser radiation light.

3. The laser of claim 1 wherein said gain medium and said saturable absorber are two separate materials comprised of dopants in a common host and wherein said gain medium and said saturable absorber are joined by diffusion bonding..

4. The laser of claim 3 wherein said gain medium is doped with $Yb^{3}+$ and said saturable absorber is doped with Cr^{4+}

5. The laser of claim 3 wherein said host material comprises of YAG.

6. The laser of claim 1 wherein said gain medium and said saturable absorber are the same crystal.

7. The laser of claim 1 wherein said gain medium is diffusion bonded on said saturable absorber.

8. The laser of claim 1, wherein the outer parts of the said laser are composed of undoped pieces of on which dielectric coatings are disposed

9. The laser of claim 1 wherein said pump source comprises an optical fiber for transmitting pump light energy; said optical fiber being optically coupled to said first mirror for pumping said gain medium with said light energy.

10. The laser of claim 9 wherein said optical coupling between said optical fiber and said first mirror is without intermediate focussing optics.

11. The laser of claim 1 wherein the outer parts of undoped YAG pieces of said microlaser are diffusion bonded on said gain medium and said saturable absorber

12. The laser of claim 1 wherein the coatings of said microlaser are applied on the undoped YAG pieces

13. The laser of claim 1 wherein said resonant cavity is less than 10 mm length.

14. The laser of claim 1 wherein said gain medium comprises a solid-state material.

15. The laser of claim 14 wherein said gain medium is consisting of Yb^3+:YAG optical material

16. The laser of claim 1 wherein said saturable absorber comprises a solid-state material.

17. The laser of Claim 16 wherein said saturable absorber is selected from the group consisting of Cr^{3+}:YAG, LiF:F_2

18. The laser of claim 1 wherein said mirrors are flat, convex-plano, or convex-convex.

19. A passively Q-switched laser based on Yb:YAG as the gain medium comprising:

a) a resonant cavity formed between a first mirror and a second mirror;

b) a gain medium disposed within said resonant cavity for producing laser gain;

c) a laser- diode pump source for energizing said gain medium; and

d) a saturable absorber disposed within said resonant cavity; said saturable absorber, said second mirror, and said laser gain being selected so that output pulses having a power greater than about 100 kilowatts are generated.

e) two undoped pieces disposed within the resonator cavity, diffusion bonded to the said saturable absorber and gain medium. The said first and second mirror are the dielectric coatings disposed on the undoped pieces outer surfaces

20. The laser of claim 19 wherein said second mirror 20 is of reflectivity R, where R is chosen in to be approximately less or equal to the unbleached transmission of saturable absorber

21. A passively Q-switched laser comprising:

a) a resonant cavity formed between a first mirror and a second mirror;

b) a gain medium disposed within said resonant cavity for producing laser gain;

e) a laser-diode pump source for energizing said gain medium; and

d) a saturable absorber disposed within said resonant cavity; said saturable absorber, said second mirror, and said laser gain being selected so that output pulses having a peak power greater than about 100,000 times said laser-diode pump power are generated.

22. The laser of claim 21 wherein said second mirror is of reflectivity R, where $R \leq T_{sa,closed}$, and $T_{sa,closed}$ is the initial , unbleached transmission of said saturable absorber to the microlaser radiation light.

If a saturable-absorber material 7 is chosen which is non-absorbing of light at the pump frequency, then the placement of the gain medium 5 and saturable-absorber material 7 may be reversed so that the gain medium 5 is disposed adjacent to the output face 9 or undoped piece 8 and the saturable-absorber material is disposed adjacent to the pump-side face 3 or undoped piece 4.

Another preferred embodiment of the microlaser is shown on FIG. 3. The laser diode bar with typical size of the bar of 10 mm is disposed in immediate contact with microlaser cavity. The microlaser cavity is also designed geometrically to be elongated in the direction of diode bar longest side. Each diode in the bar may produce enough radiation to form the separate microlaser cavity. The emission from microlaser can be upscaled in this design in terms of output power. Also this pattern of emission can be conveniently match and effectively coupled into frequency down-converting crystal. The frequency down-conversion can be realized by virtue of optical parametric amplification, by positioning for example, periodically poled $LiNbO_3$ or periodically-poled KTP crystal in immediate contact with respect to output 10 of microlaser. Multiwatt output powers with average pulse repetition rate equal to the pulse repetition rate out of individual microlaser cavity multiplied by the number of lasing cavities can be generated.

The extremely short pulses make the microlaser device attractive for many bio-medical application, including dentistry, delicate skin-treatments, skin resurfacing, cardiovascular revasculation, inner ear surgery and many others. Scientific, aeronautic, space applications may include high-precision optical ranging, robotic vision and automated production.

Additional embodiments include:

23. A passively Q-switched laser comprising:

a) a resonant cavity formed between a first mirror and a second mirror; said second mirror having a reflectivity $R \leq T_{sa,closed}$, and $T_{sa,closed}$ is the initial , unbleached transmission of said saturable absorber to the microlaser radiation light.

b) a gain medium disposed within said resonant cavity for producing laser gain;

c) a pump source for energizing said gain medium; and

d) a saturable absorber disposed within said resonant cavity; said saturable absorber preventing the onset of said pulses until the average inversion density within said resonant cavity reaches a certain threshold value.

24. A passively Q-switched laser for producing high-peak-power pulses of light comprising:

a) a resonant cavity formed between a first mirror and a second mirror;

b) a gain medium disposed within said resonant cavity for producing laser gain;

c) a pump source for energizing said gain medium; and

d) a saturable absorber disposed within said resonant cavity; said saturable absorber, said second mirror, and said laser gain being selected so that output pulses having a duration of less than about 1 nanosecond are generated; said gain medium and said saturable absorber being two separate materials comprised of dopants in a common host; said gain medium and said saturable absorber being bonded by diffusion bonding.

25. A passively Q-switched laser for producing high-peak-power pulses of light comprising:

a) a resonant cavity formed between a first mirror and a second mirror;

b) a gain medium disposed within said resonant cavity for producing laser gain;

c) a laser diode pump source for energizing said gain medium; and

d) a saturable absorber disposed within said resonant cavity; said saturable absorber, said second mirror, and said laser gain being selected so that output pulses having a peak power of greater than about 10,000 times said laser diode pump power are generated; said gain medium and said saturable absorber being two separate materials comprised of dopants in a common host; said gain medium and said saturable absorber being bonded by diffusion bonding.

26. A passively Q-switched laser for producing high-peak-power pulses of light, comprising:

a) a gain medium having opposed first and second faces for producing laser gain from light emitted by a pump source; said first face being highly transmissive to light emitted from said pump and being highly reflective to light at the lasing wavelength; and

b) a saturable absorber having opposed first and second faces; said first face of said saturable absorber being disposed adjacent said second face of said gain medium at an interface; said interface being highly transmissive of light at said lasing wavelength; said second face of said saturable absorber having a reflectivity R, where R is chosen close to initial saturable absorber transmission

-27. A method of forming a passively Q-switched laser comprising the steps of:

a) forming a resonant cavity between a first mirror and a second mirror;

b) disposing a gain medium within said resonant cavity for producing laser gain;

c) energizing said gain medium with a pump source; and

d) disposing a saturable absorber within said resonant cavity; selecting said saturable absorber, said second mirror, and said laser gain so that output pulses having a duration of less than about 1 nanosecond are generated

28. The method of claim 27 wherein said second mirror is an output coupler having reflectivity $R \leq T_{sa,closed}$, where $T_{sa,closed}$ is the initial , unbleached transmission of said saturable absorber to the microlaser radiation light.

29. The method of claim 27 further comprising the step of diffusion bonding said gain medium and said saturable absorber wherein said gain medium and said saturable absorber are two separate materials comprised of dopants in a common host.

30. The method of claim 27 wherein said gain medium and said saturable absorber are the same crystal.

31. The method of claim 27 wherein said pump source comprises an optical fiber for transmitting pump light energy; said optical fiber being optically coupled to said first mirror for pumping said gain medium with said light energy.

32. The method of claim 27 further comprising the step of disposing nonlinear optical crystals in proximity with said second mirror for frequency conversion of said pulses emitted by said laser.

33. A method for forming a passively Q-switched laser comprising the steps of:

a) forming a resonant cavity between a first mirror and a second mirror;

b) disposing a gain medium within said resonant cavity for producing laser gain;

c) energizing said gain medium with a laser diode pump source; and

d) disposing a saturable absorber within said resonant cavity; selecting said saturable absorber, said second mirror, and said laser gain so that output pulses having a peak power greater than about 100 kilowatt are generated.

34. The method of claim 33 wherein said second mirror comprises an output coupler having reflectivity R,

35. A method for forming a passively Q-switched laser comprising the steps of:

a) forming a resonant cavity between a first mirror and a second mirror;

b) disposing a gain medium within said resonant cavity for producing laser gain;

c) energizing said gain medium with a laser-diode pump source; and

d) disposing a saturable absorber within said resonant cavity; selecting said saturable absorber, said second mirror, and said laser gain that output pulses having a peak power greater than about 10,000 times said laser-diode pump power are generated.

36. The method of claim 35 wherein said second mirror comprises an output coupler having reflectivity R, where $R \leq T_{sa,closed}$, and $T_{sa,closed}$ is the initial , unbleached transmission of said saturable absorber to the microlaser radiation light.

a) forming a gain medium having opposed first and second faces for producing laser gain from light emitted by a pump source; said first face being highly transmissive to light emitted from said pump and being highly reflective to the light at the lasing wavelength; and

b) disposing a saturable absorber having first and second faces adjacent to said gain medium; and one of the undoped pieces, said first face of said saturable absorber being disposed adjacent to said second face of said gain medium at an interface; said interface being highly reflective of light at said lasing wavelength; said second face of said saturable absorber having a reflectivity R $R \leq T_{sa,closed}$, where $T_{sa,closed}$ is the initial , unbleached transmission of said saturable absorber to the microlaser radiation light..

It will be understood by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather, the scope of the present invention includes both combinations and sub-combinations of the various features described hereinabove, as well as variations and modifications thereof that are not in the prior art which would occur to persons skilled in the art upon reading the foregoing description.